Reduction & Analysis of PDV data from Ring expansion test

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Outline

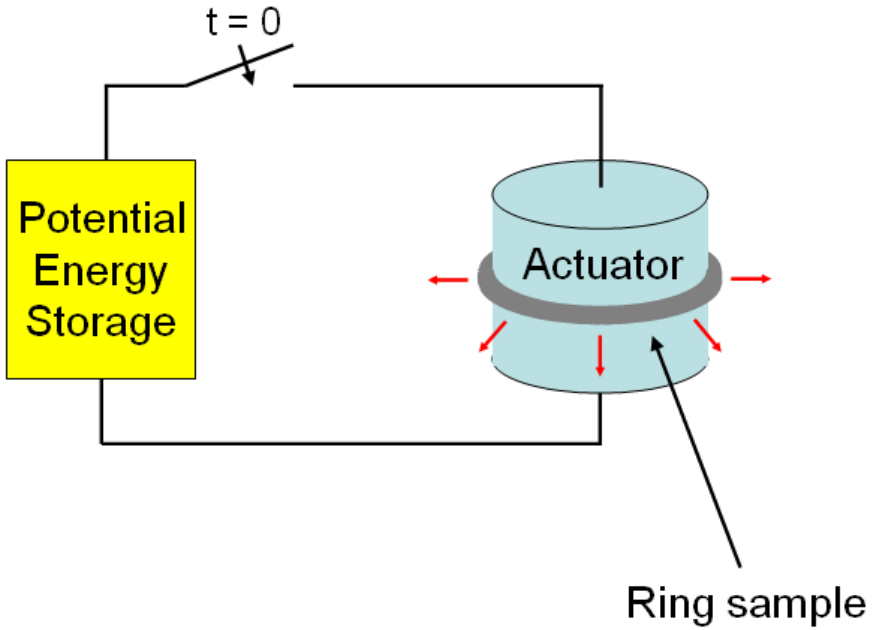
- Motivation
- Methods
- Results
- Discussion
- Conclusion

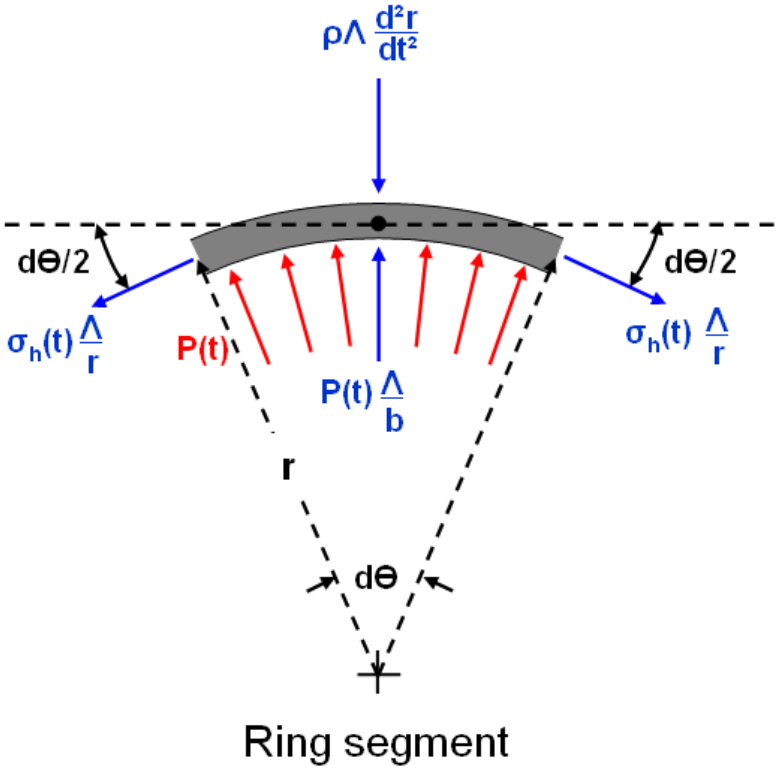
Motivation

- Develop MATLAB code for automated analysis of ring expansion PDV data for the determination materials constitutive properties
- Design and deployment of stand alone test systems for high strain rate materials behavior
- Wave free uniform tension test method to compare/supplant split Hopkinson pressure bar technique

Method

Free Body Diagram





$$\Lambda = bhrd\theta$$

$$\downarrow$$

$$\rho\Lambda\frac{d^2r}{dt^2} = P(t)\frac{\Lambda}{b} - \sigma_h(t)\frac{\Lambda}{r} \quad \rightarrow \text{For } P(t) \approx 0 \rightarrow \quad \boxed{\sigma_h(t) = -r\rho\frac{d^2r}{dt^2}}$$

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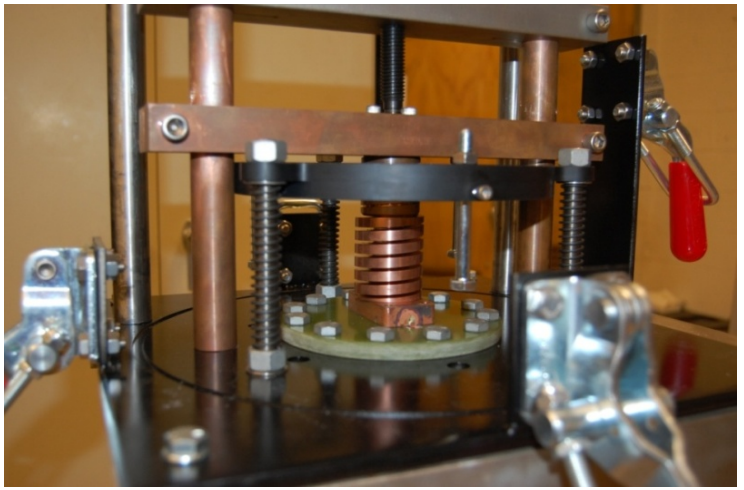
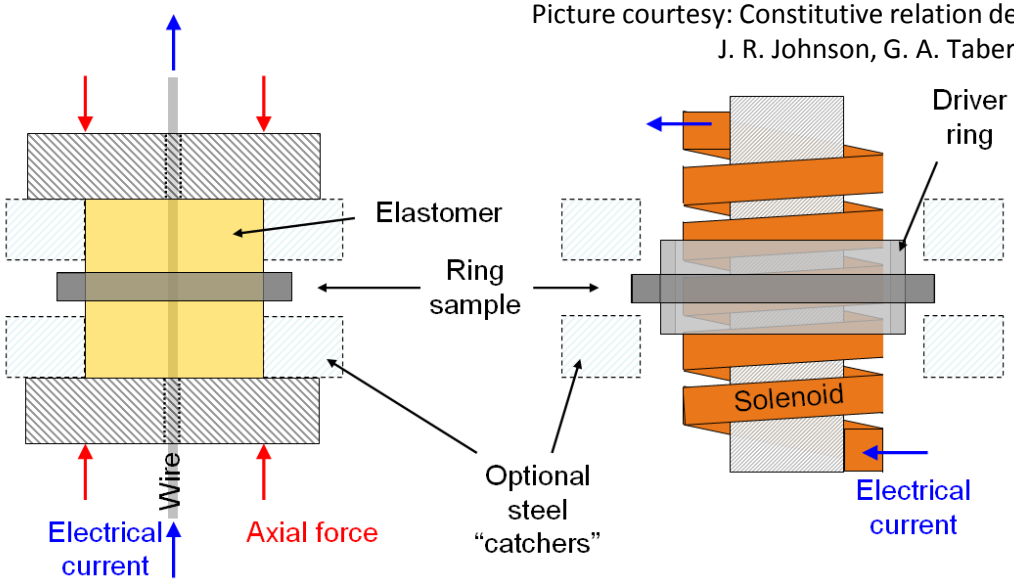
Experimental Setup

Vaporizing wire technique



Electromagnetic ring expansion

Picture courtesy: Constitutive relation development through the FIRE test
J. R. Johnson, G. A. Taber, and G. S. Daehn



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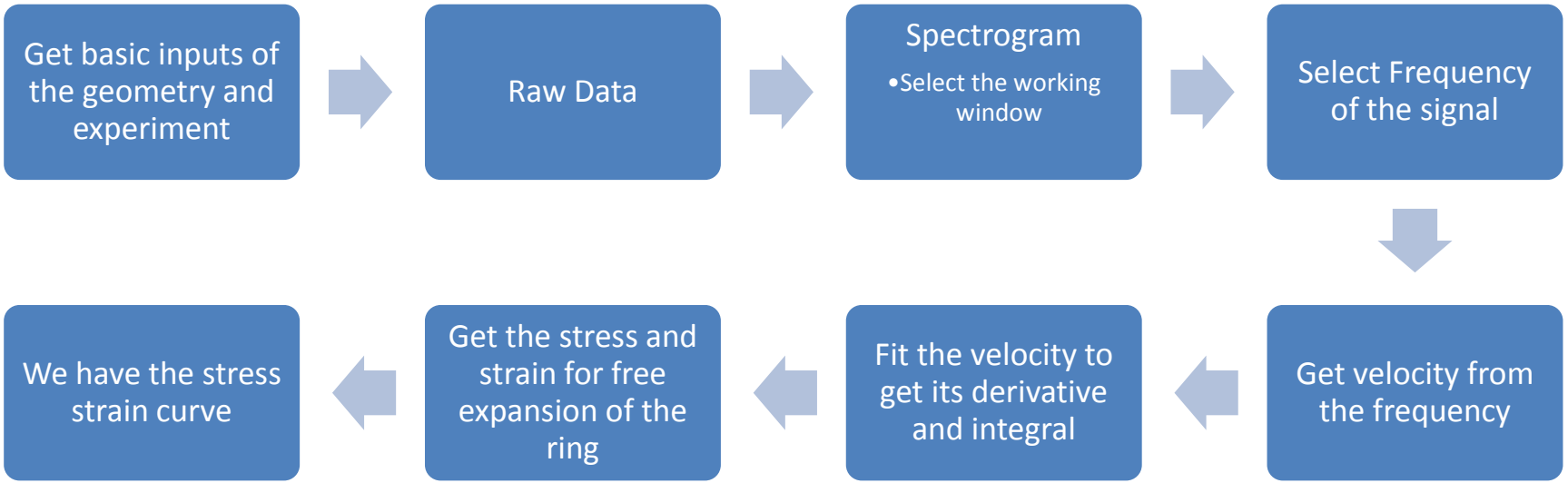
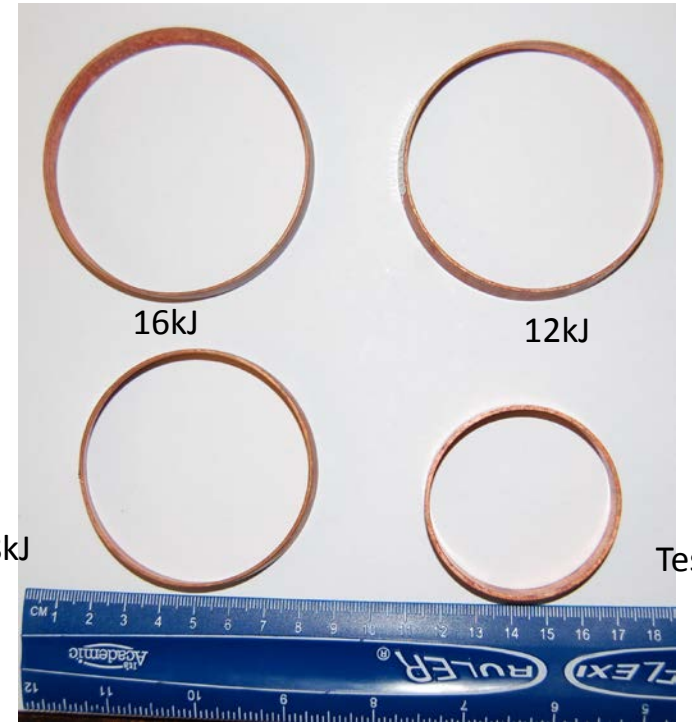
Flowchart for data reduction



Results

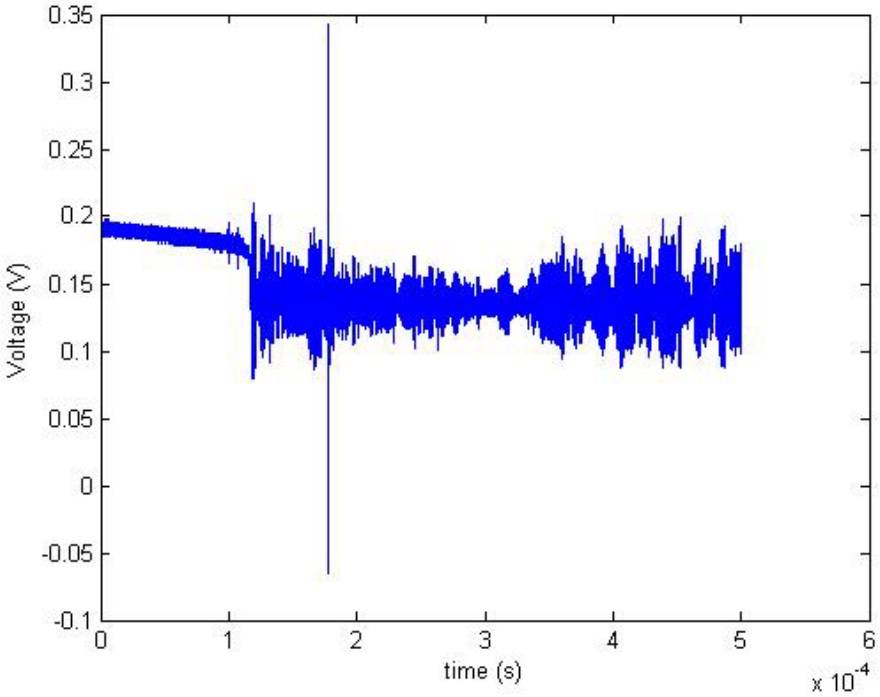
Annealed Cu 101 rings

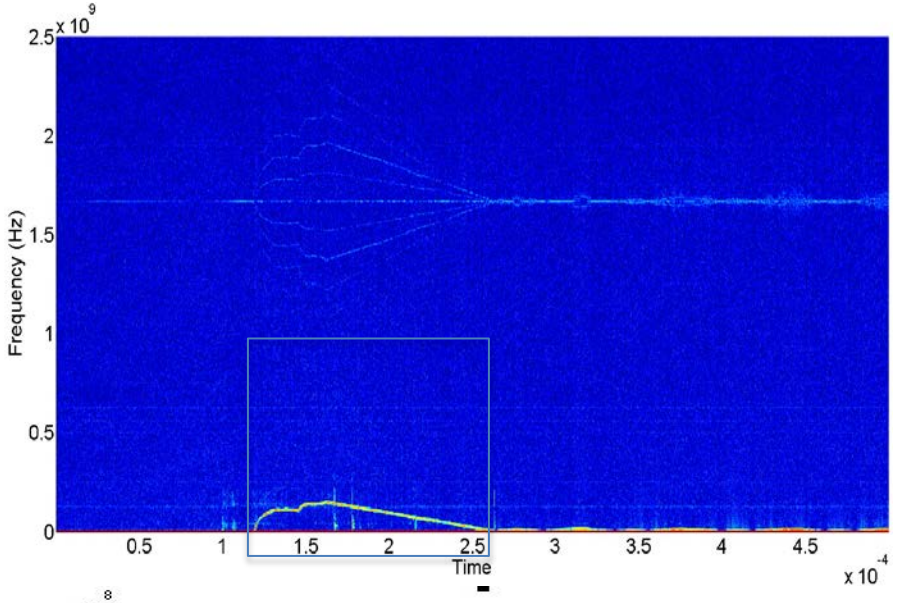
- 50.5mm I.D. x 53.34mm O.D. x 10mm rings
- Exploding wire actuator, 0.8mm wire
- Launched with 8kJ, 12kJ and 16kJ energy

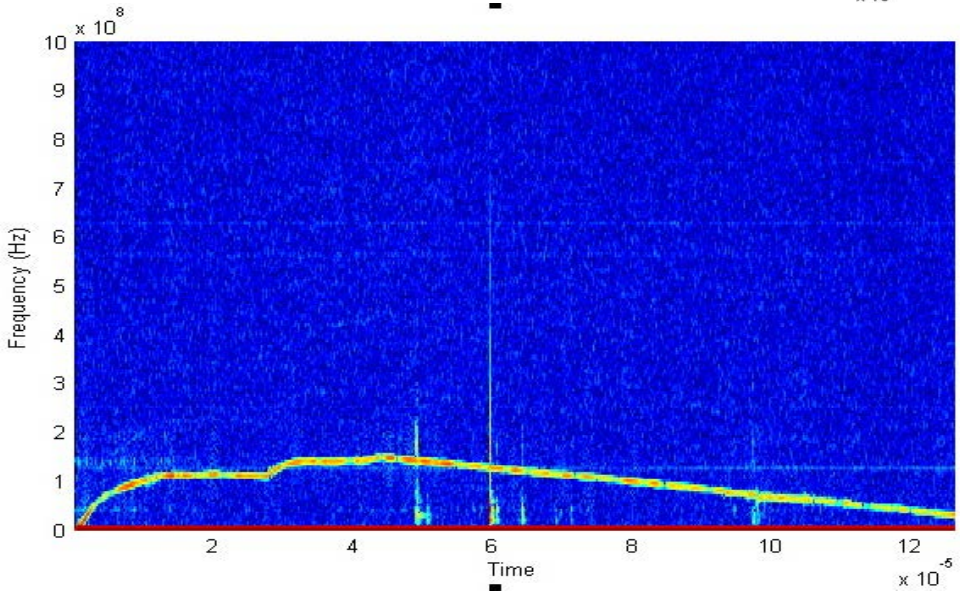


Test specimen

Raw data to spectrogram







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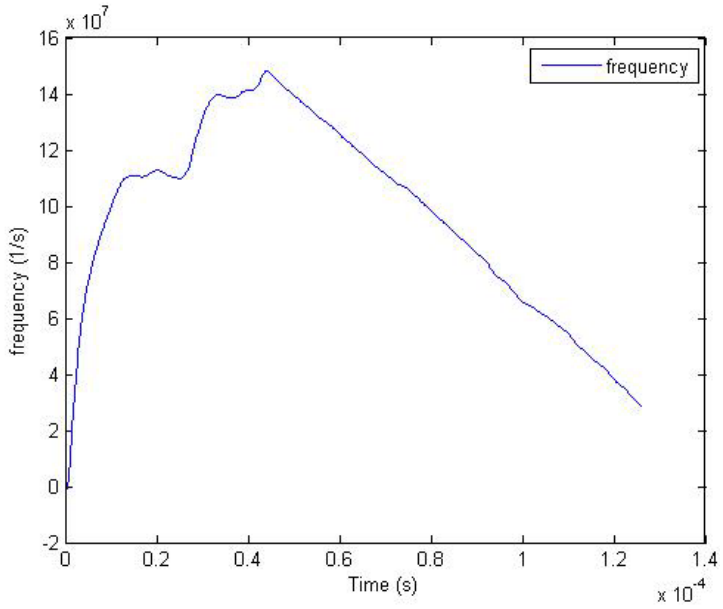
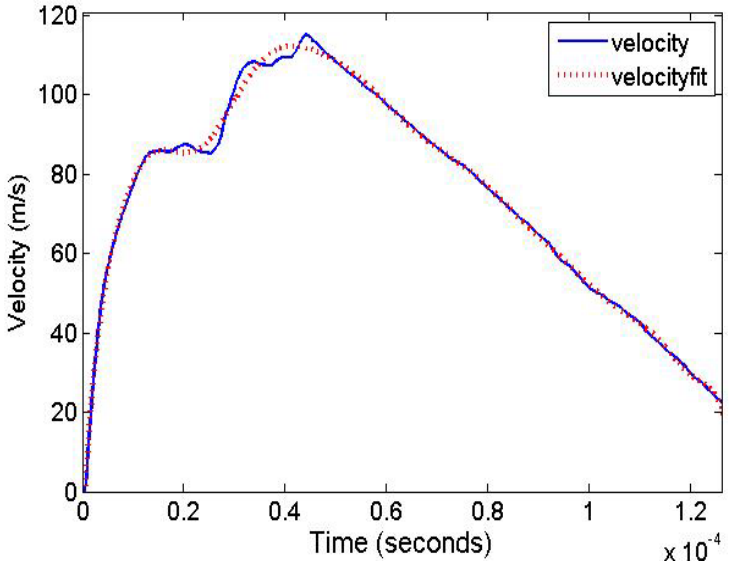
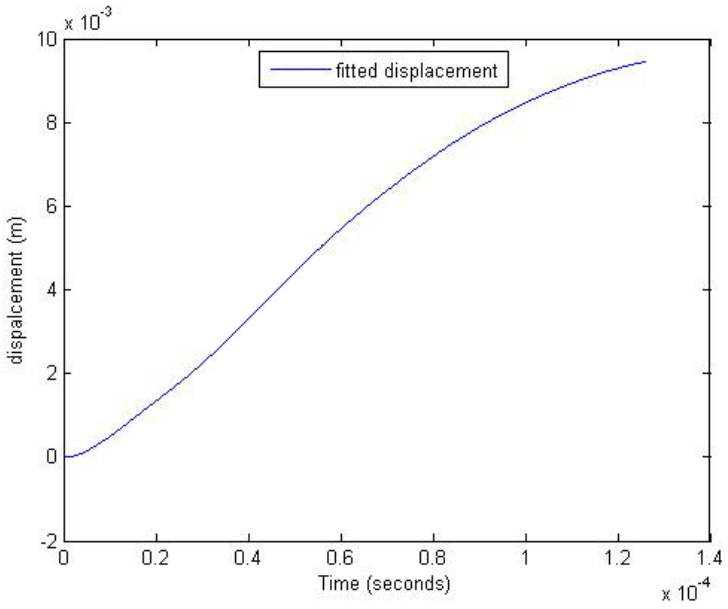
Frequency, Velocity & Displacement







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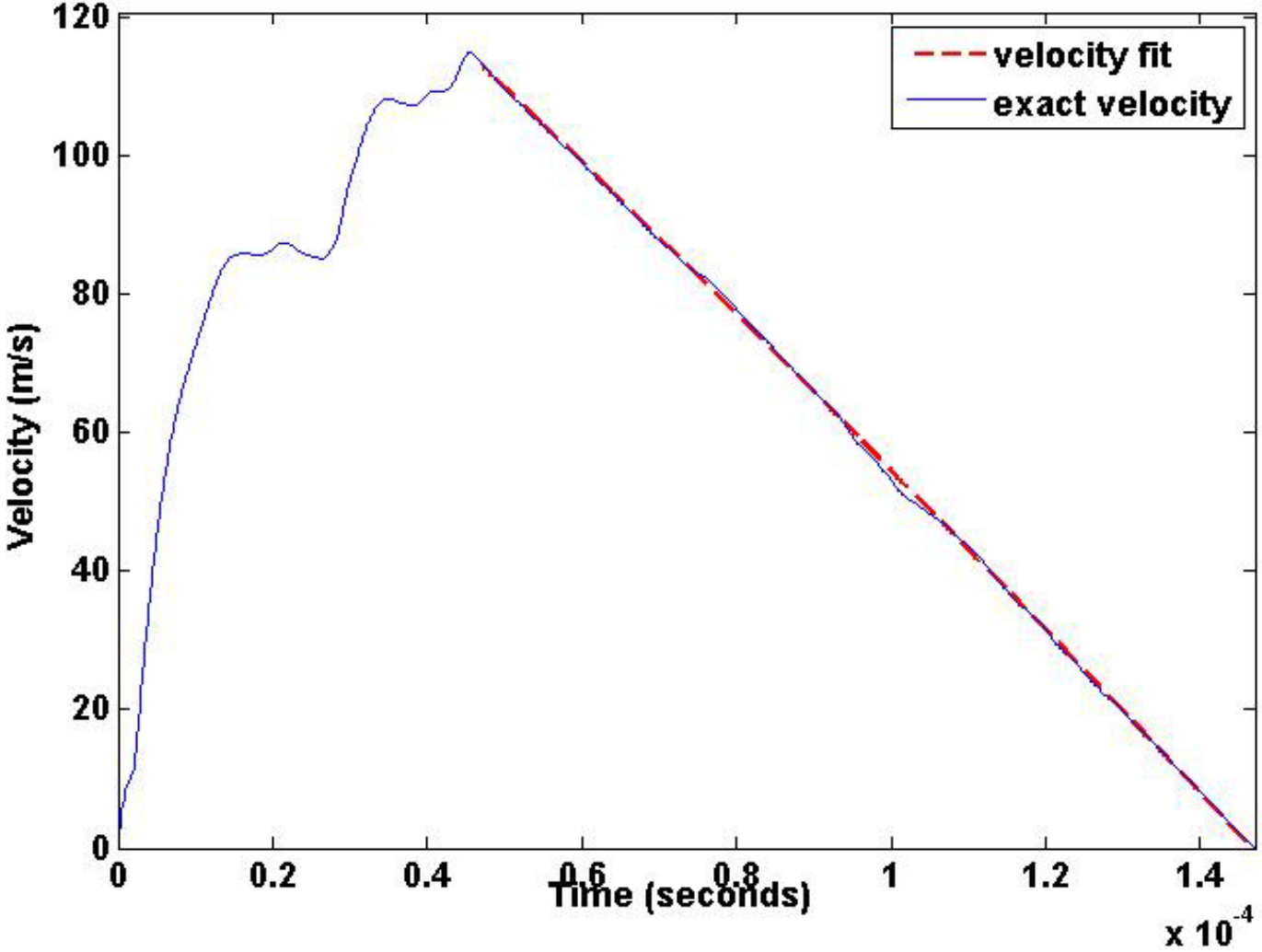
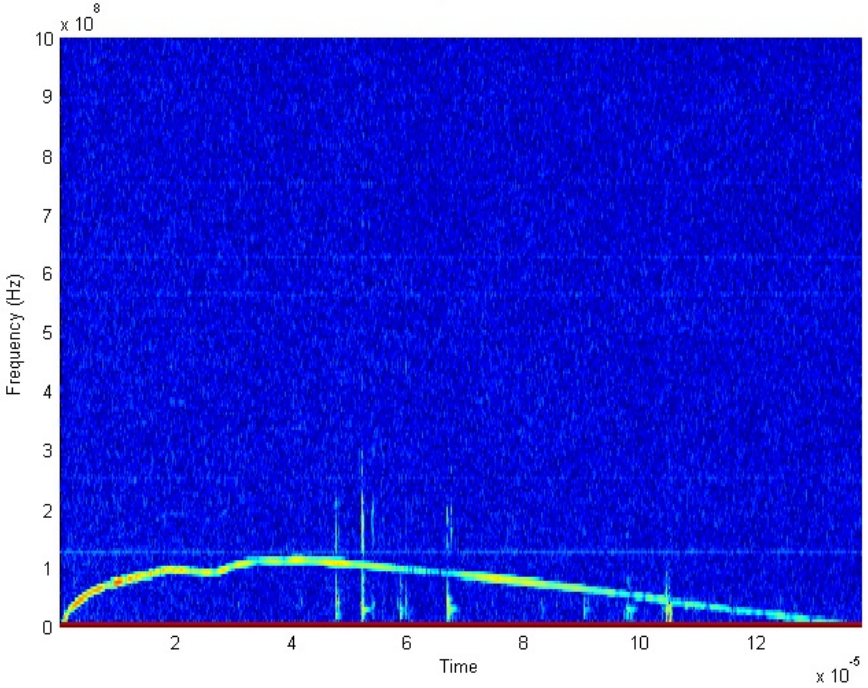
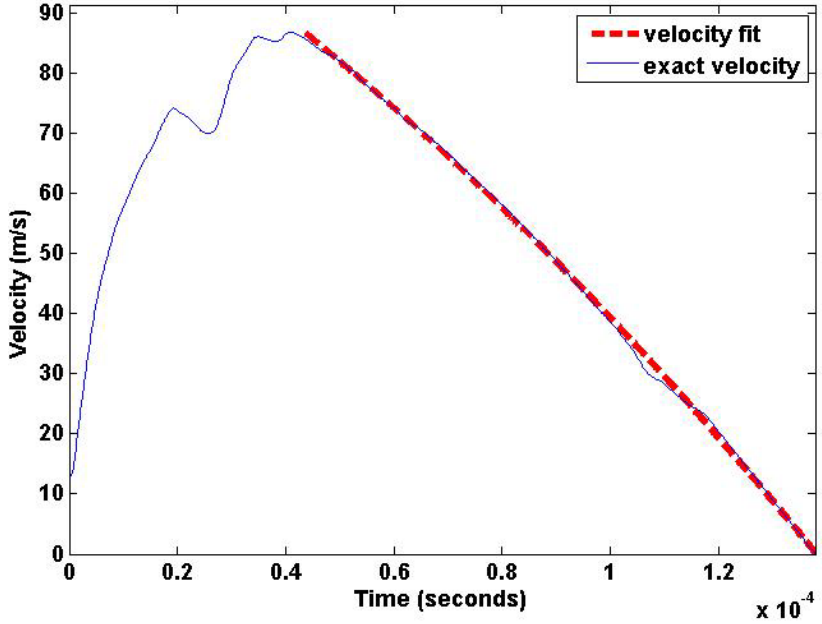
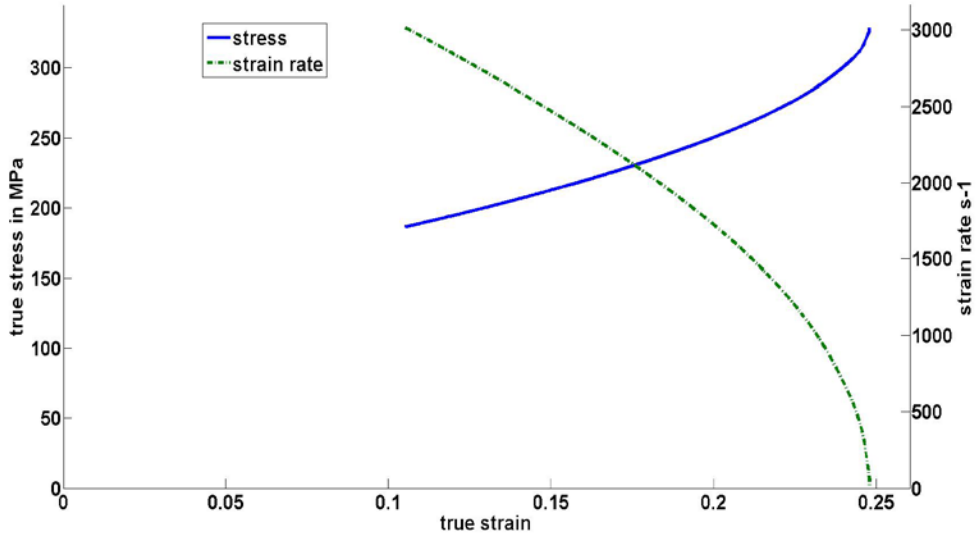
Fit velocity with quadratic fit



8kJ Cu 101







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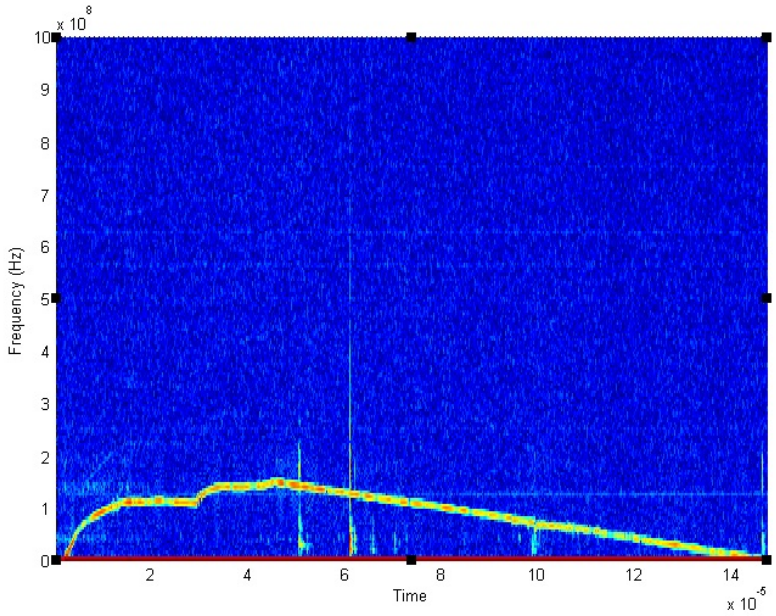
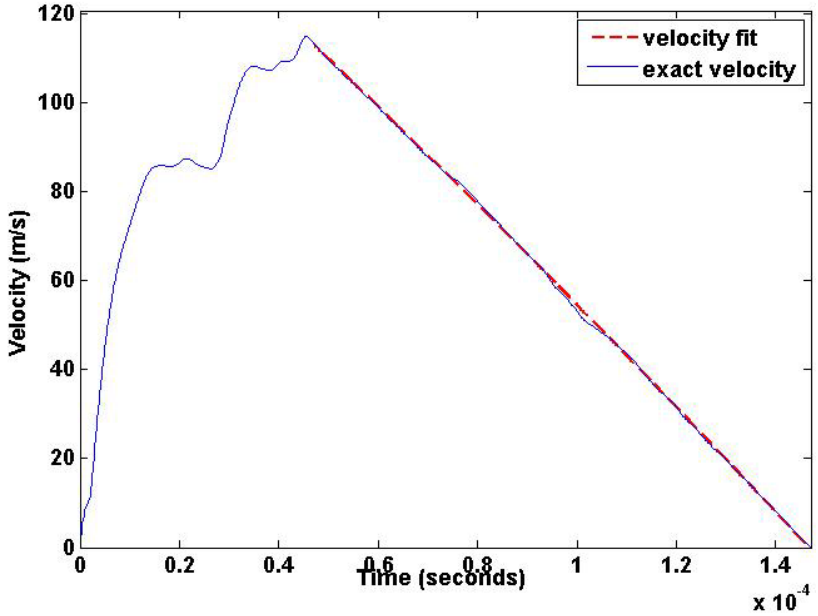
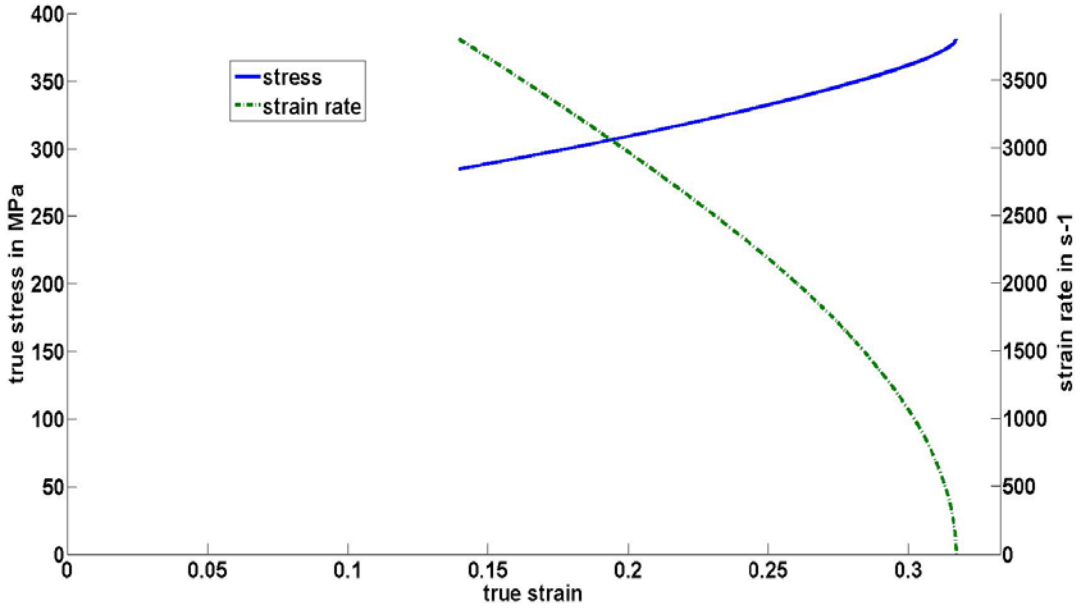
12kJ Cu 101







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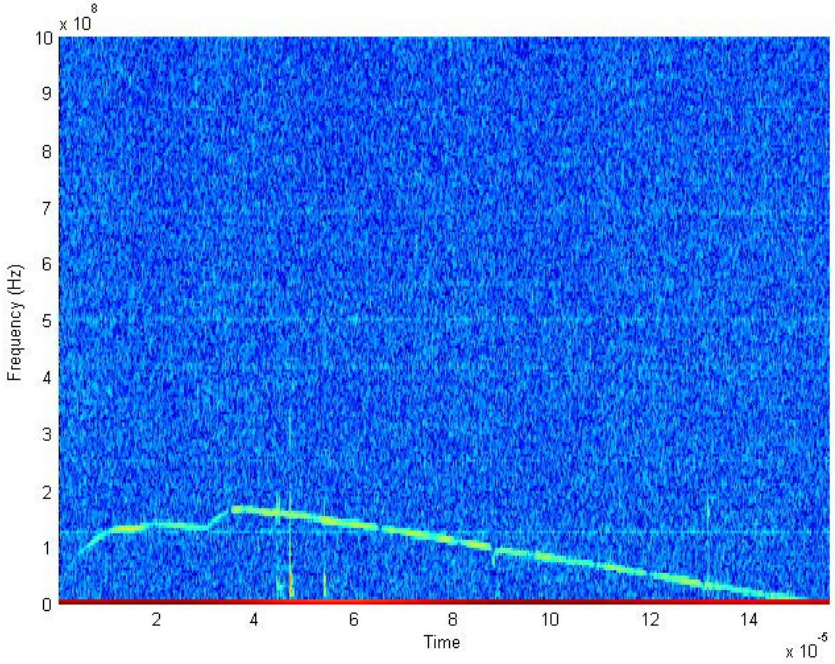
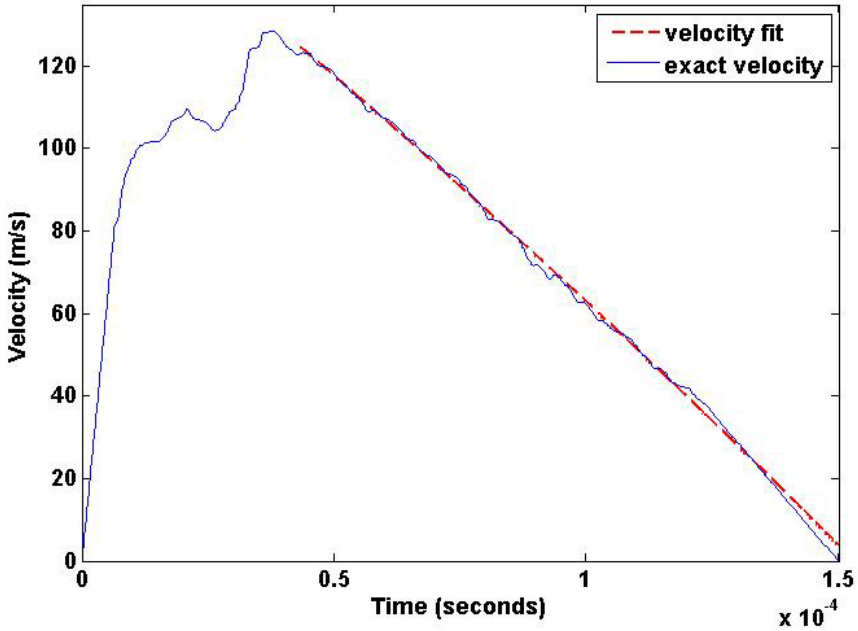
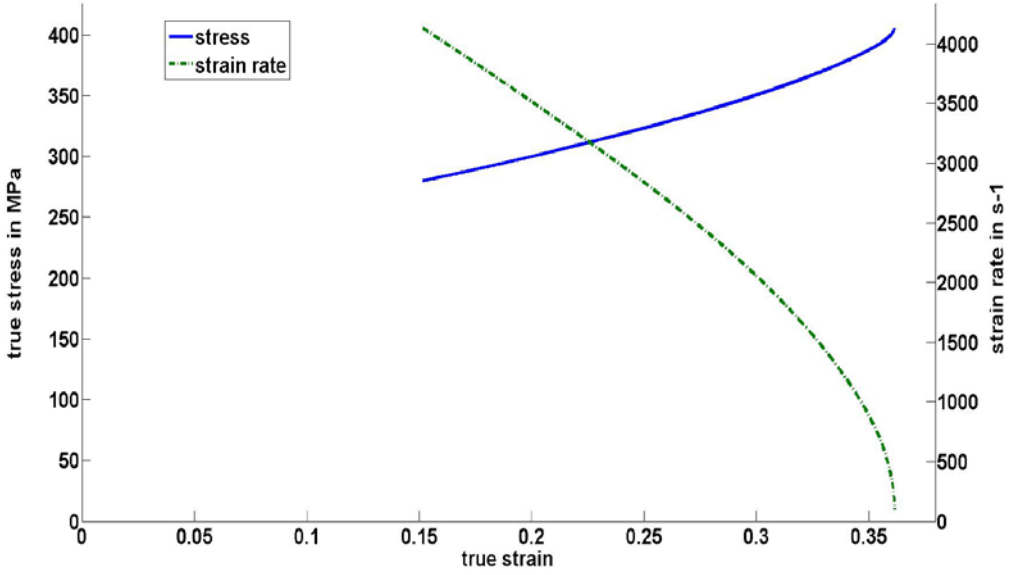
16kJ Cu 101







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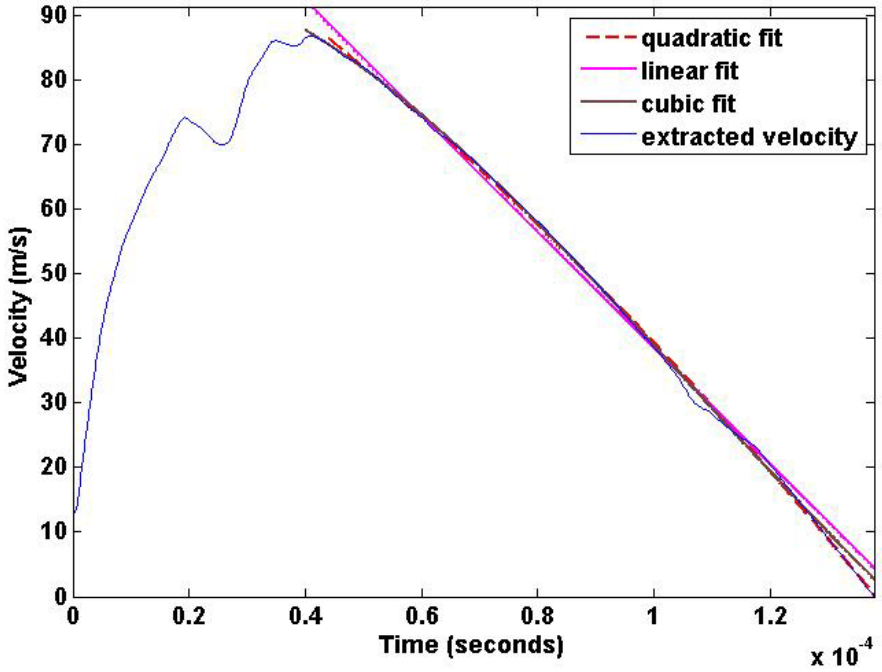
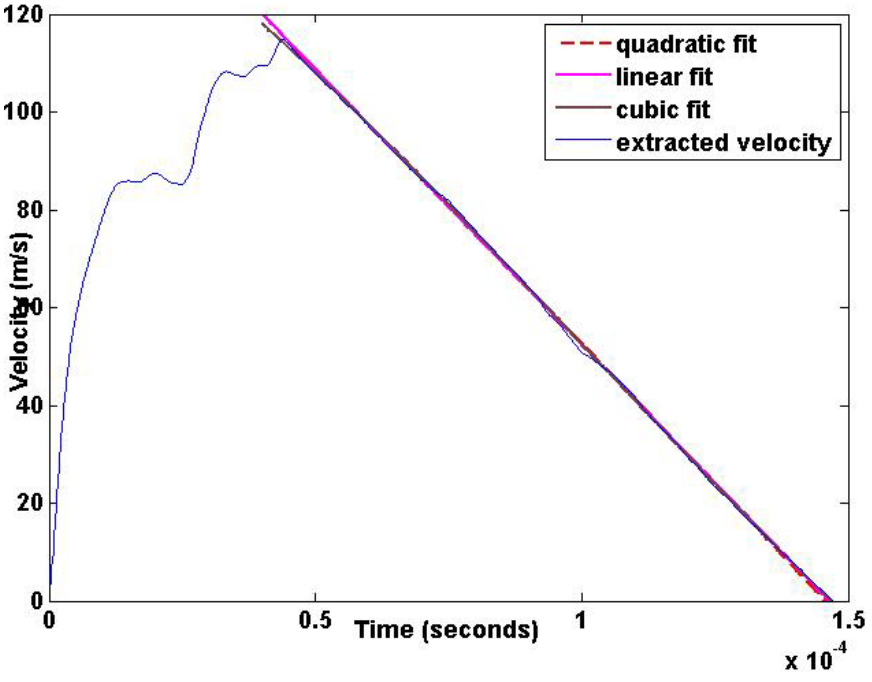
Discussion

Comparison of different fits

- Velocity plots

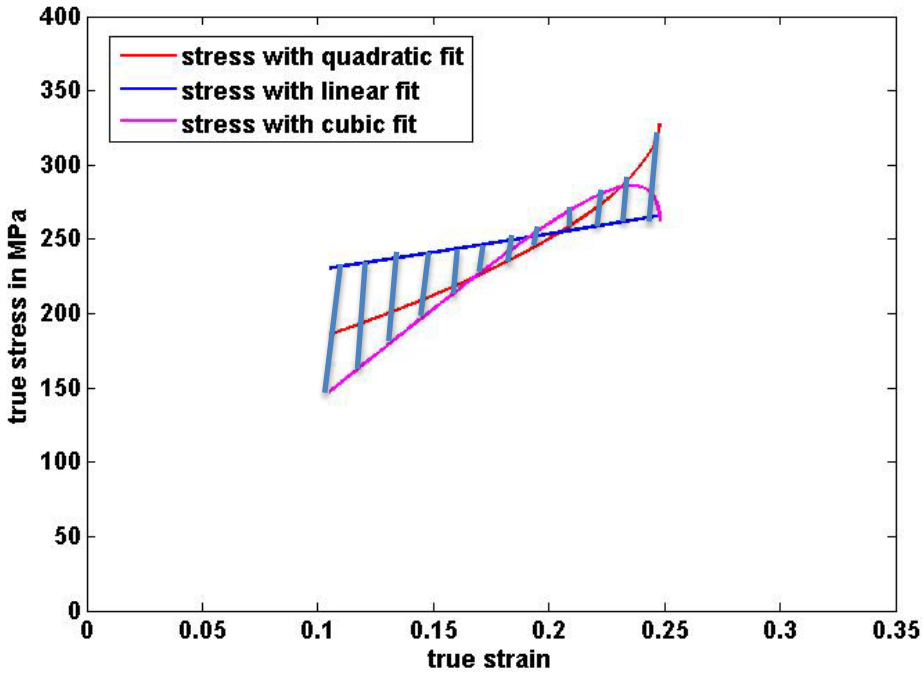


Velocity plot at 8kJ

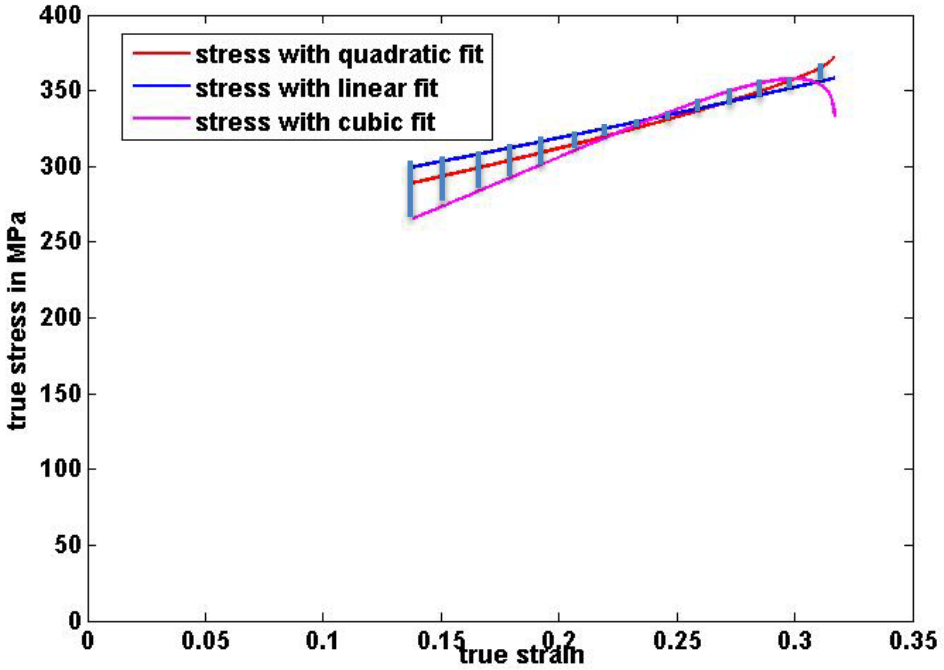


Velocity plot at 12kJ

- Stress plots

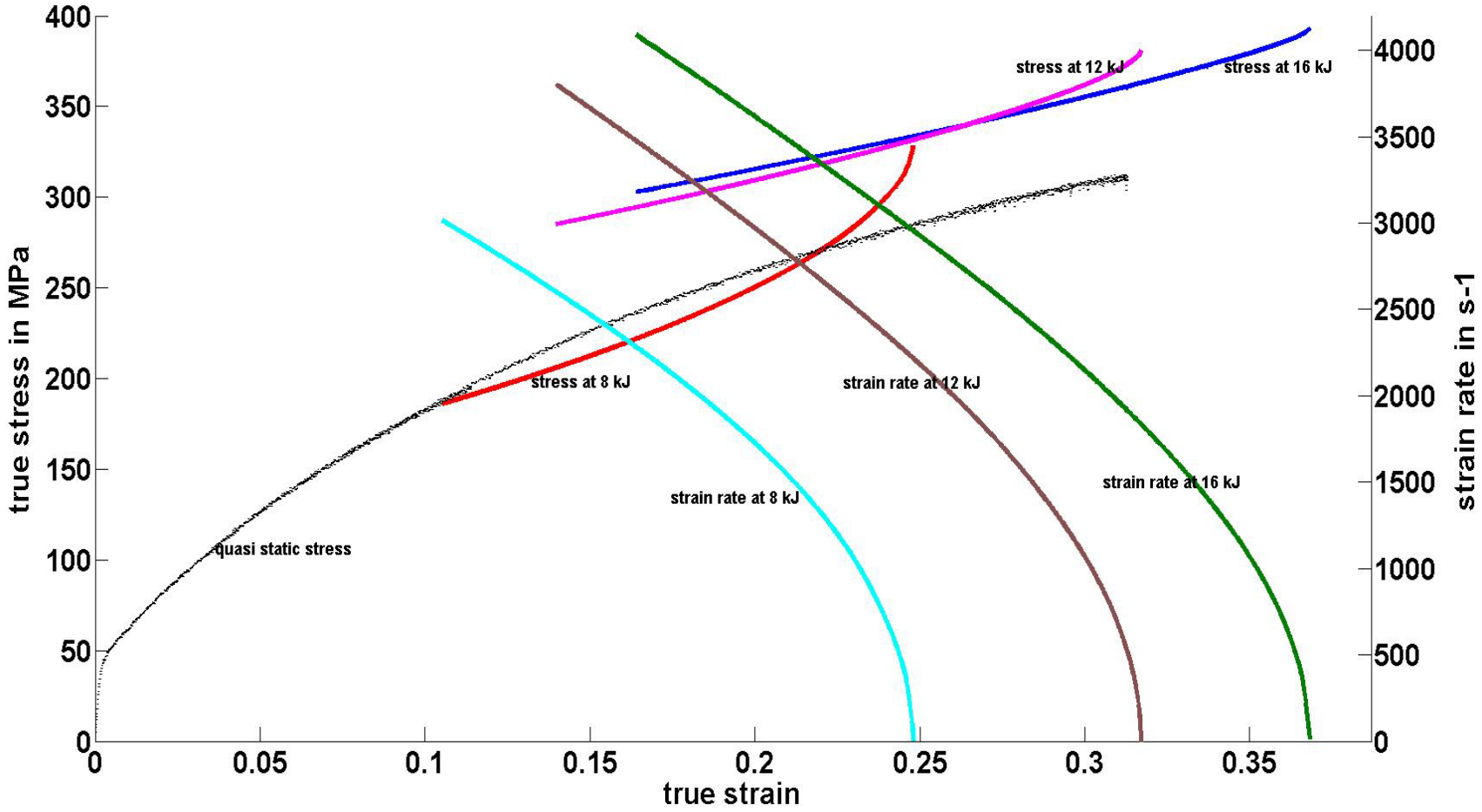


Stress plot at 8kJ



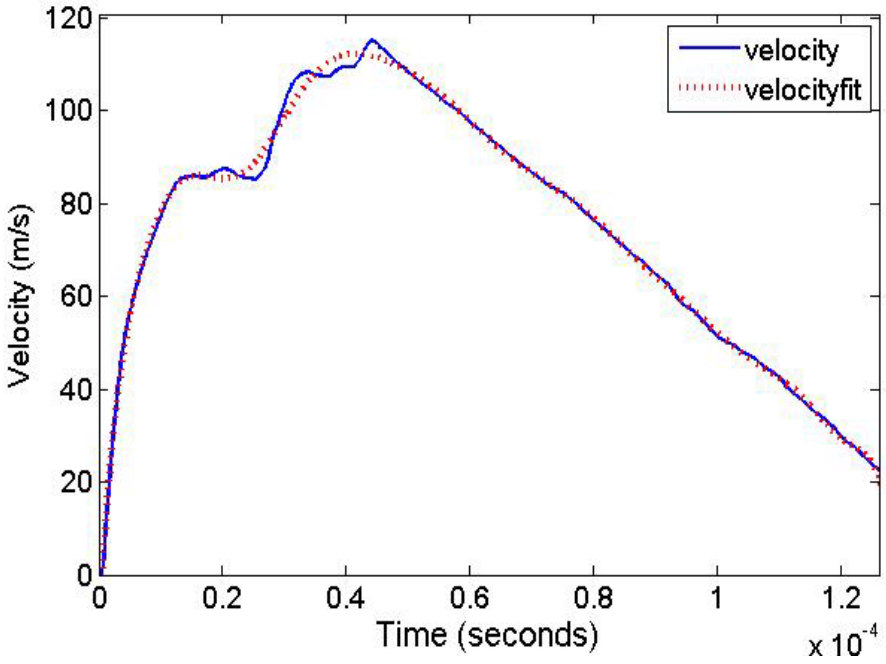
Stress plot at 12kJ

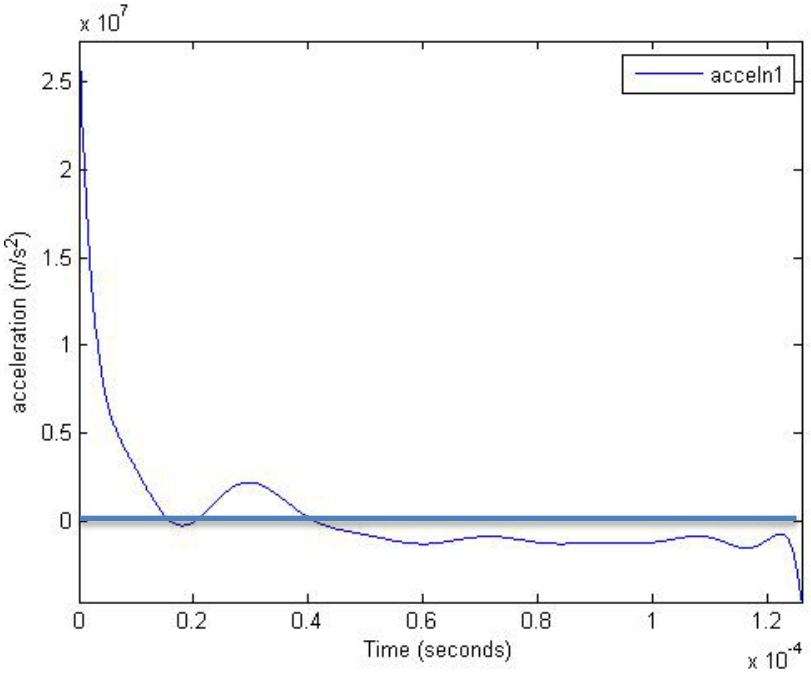
Comparing stress and strain rates for all three shots



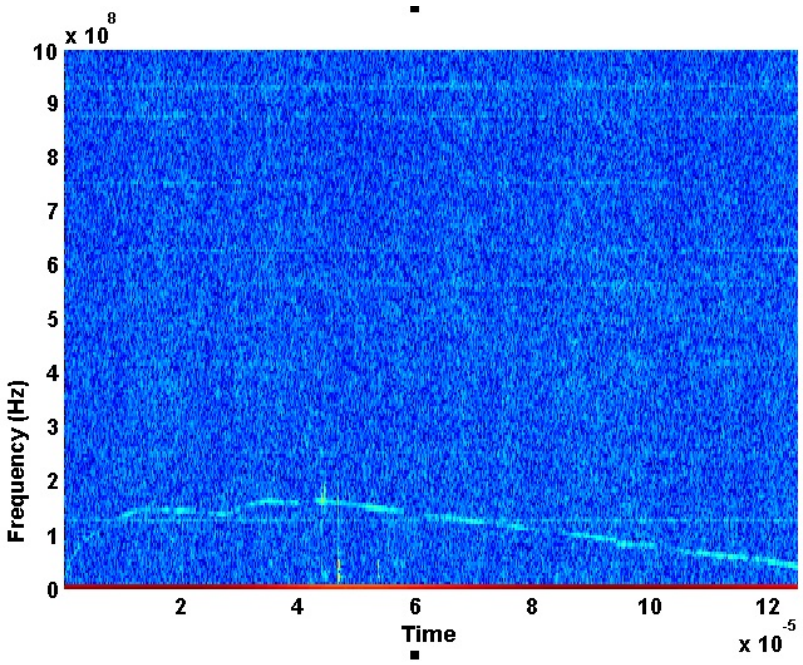
Scope of improvement

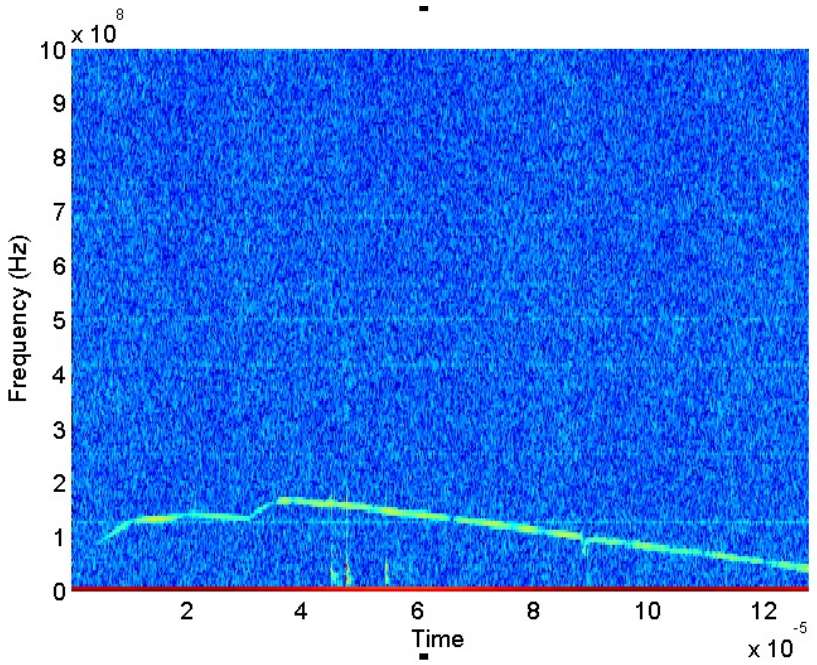
- Problem with Fourier fit

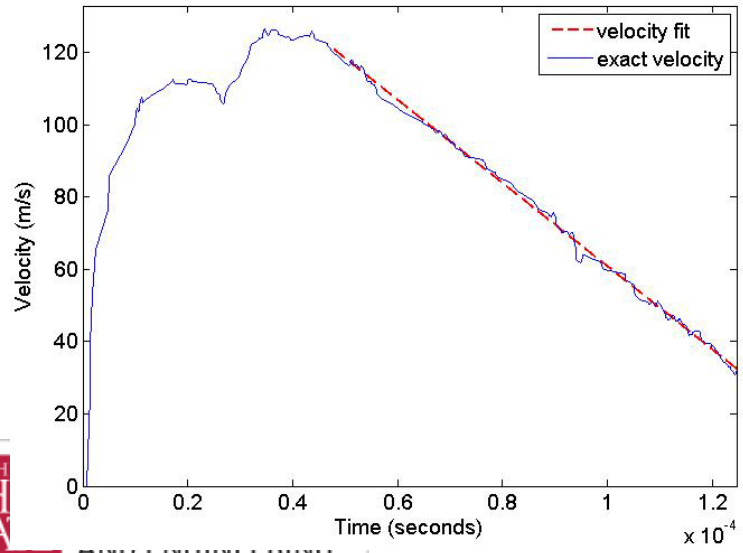


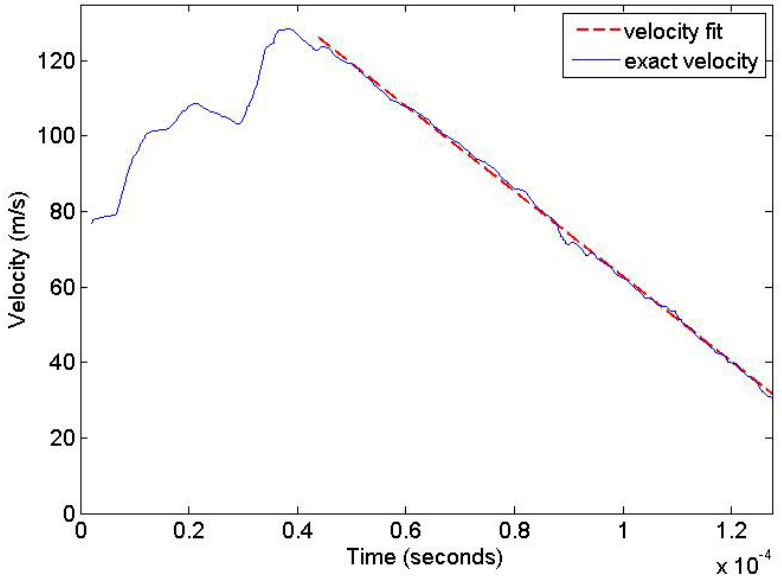


- Missing data









Conclusions

- Moving towards automatic extraction of velocity and stress-strain data from the PDV signal with minimum user intervention.
- Obtaining high-fidelity data from the PDV is important.
- Three tests with 8kJ, 12kJ and 16kJ were performed on annealed Cu101 in which maximum strain rate of about 5000 s^{-1} with a total strain about 40% was achieved .
- Very subtle variations fitting function forms, all of which fit well, give significant variations in the apparent stress-strain curve.

Questions??